PRESPLITTING
INTERIM REPORT 3

REPORT # FHWA/CA/TL-73/07

CALTRANS STUDY # F-8-7

HIGHWAY RESEARCH REPORT

PRESPLITTING

INTERIM REPORT 3

STATE OF CALIFORNIA

BUSINESS AND TRANSPORTATION AGENCY

DEPARTMENT OF PUBLIC WORKS

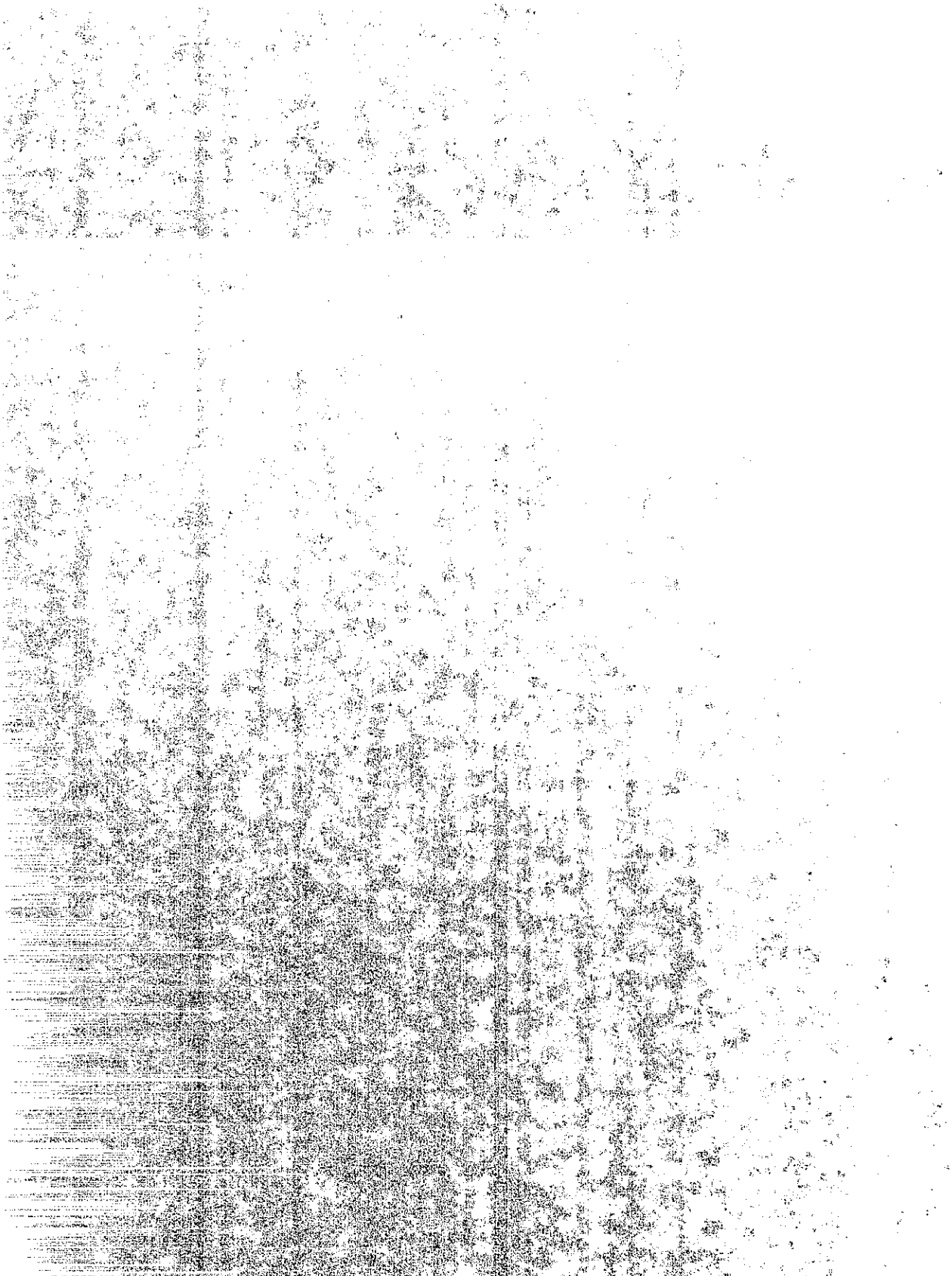
DIVISION OF HIGHWAYS

MATERIALS AND RESEARCH DEPARTMENT

RESEARCH REPORT

CA-HY-MR-2955-3-73-07

Prepared in Cooperation with the U.S. Department of Transportation, Federal Highway Administration March, 1973



TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.

4. TITLE AND SUBTITLE
Presplitting Interim Report 3

5. REPORT DATE
March 1973

6. PERFORMING ORGANIZATION CODE
19203-762503-632955

7. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NO.
CA-HY-MR-2955-3-73-07

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Materials and Research Department
California Division of Highways
Sacramento, CA 95819

10. WORK UNIT NO.

11. CONTRACT OR GRANT NO.
F-8-7

12. SPONSORING AGENCY NAME AND ADDRESS
California Division of Highways
Sacramento, CA 95807

13. TYPE OF REPORT & PERIOD COVERED
Interim Report

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
This study is being conducted in cooperation with the U.S.Department of Transportation, Federal Highway Administration.

16. ABSTRACT

This report on presplitting highway cut slopes by the California Division of Highways discusses and analyzes the construction methods and problems, the specifications, and the economics involved with the presplitting of sedimentary rocks. It is the third report in a series on presplitting in different rock types. The first two reports of similar content dealt respectively with metamorphic and granitic rock presplitting.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Construction Methods, evaluation, cuts, slopes, rock presplitting, specifications	Unlimited

19. SECURITY CLASSIF. (OF THIS REPORT)	20. SECURITY CLASSIF. (OF THIS PAGE)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	31	

HMRT – 1242 (ORIG. 9/72)

STATE OF CALIFORNIA—TRANSPORTATION AGENCY RONALD REAGAN, Governor

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DIVISION OF HIGHWAYS
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Lab Auth. 632955
F-8-7

March 1, 1973

Mr. R. J. Datel
State Highway Engineer

Dear Sir:

Submitted herewith is a research report titled:

PRESPLITTING

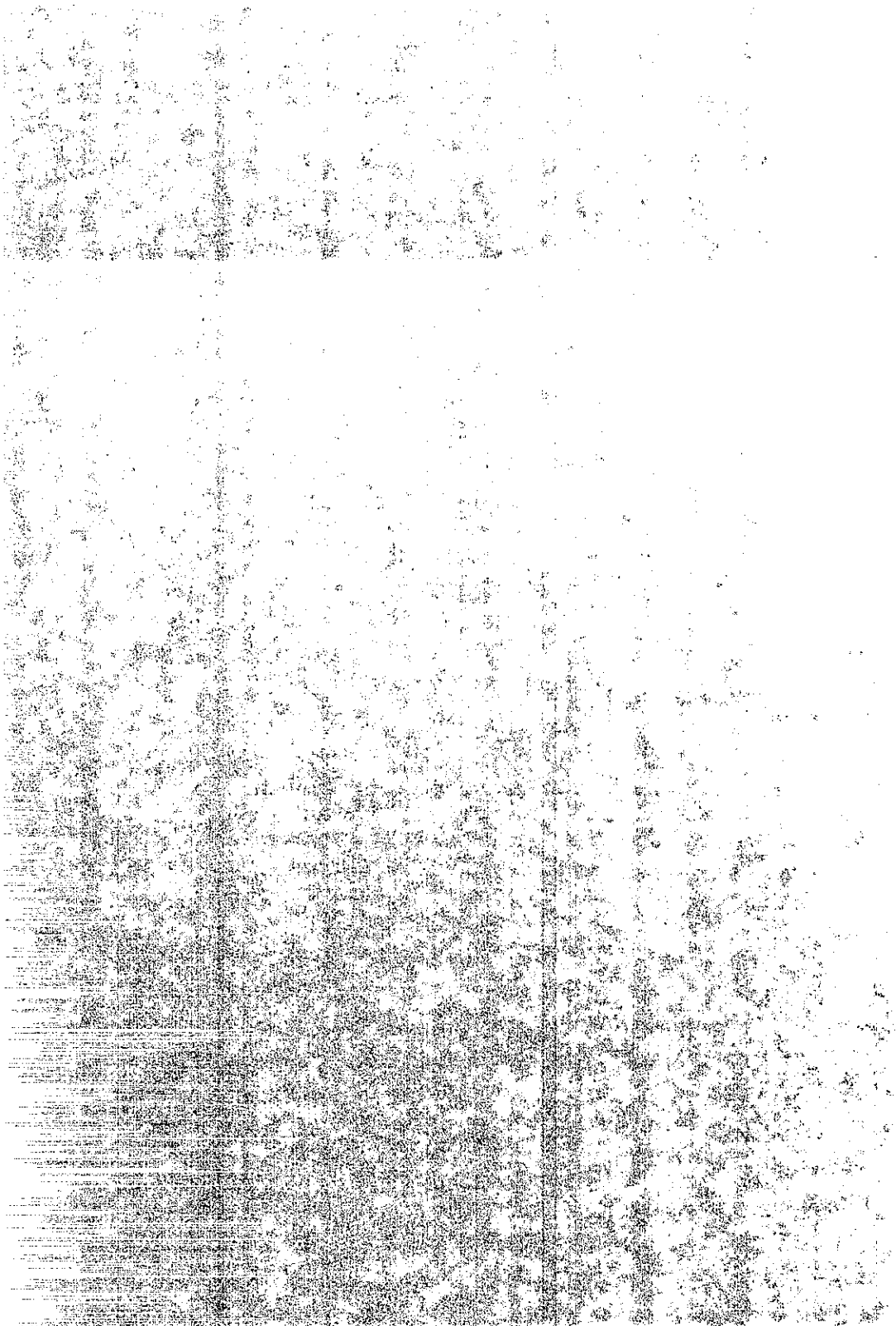
INTERIM REPORT 3

Under general direction of .....Raymond A. Forsyth
Supervised by.....Marvin L. McCauley
Principal Investigator .....Ronald W. Mearns
Report prepared by .....Ronald W. Mearns
Thomas P. Hoover

Very truly yours,

JOHN L. BEATON
Materials and Research Engineer

Attachment



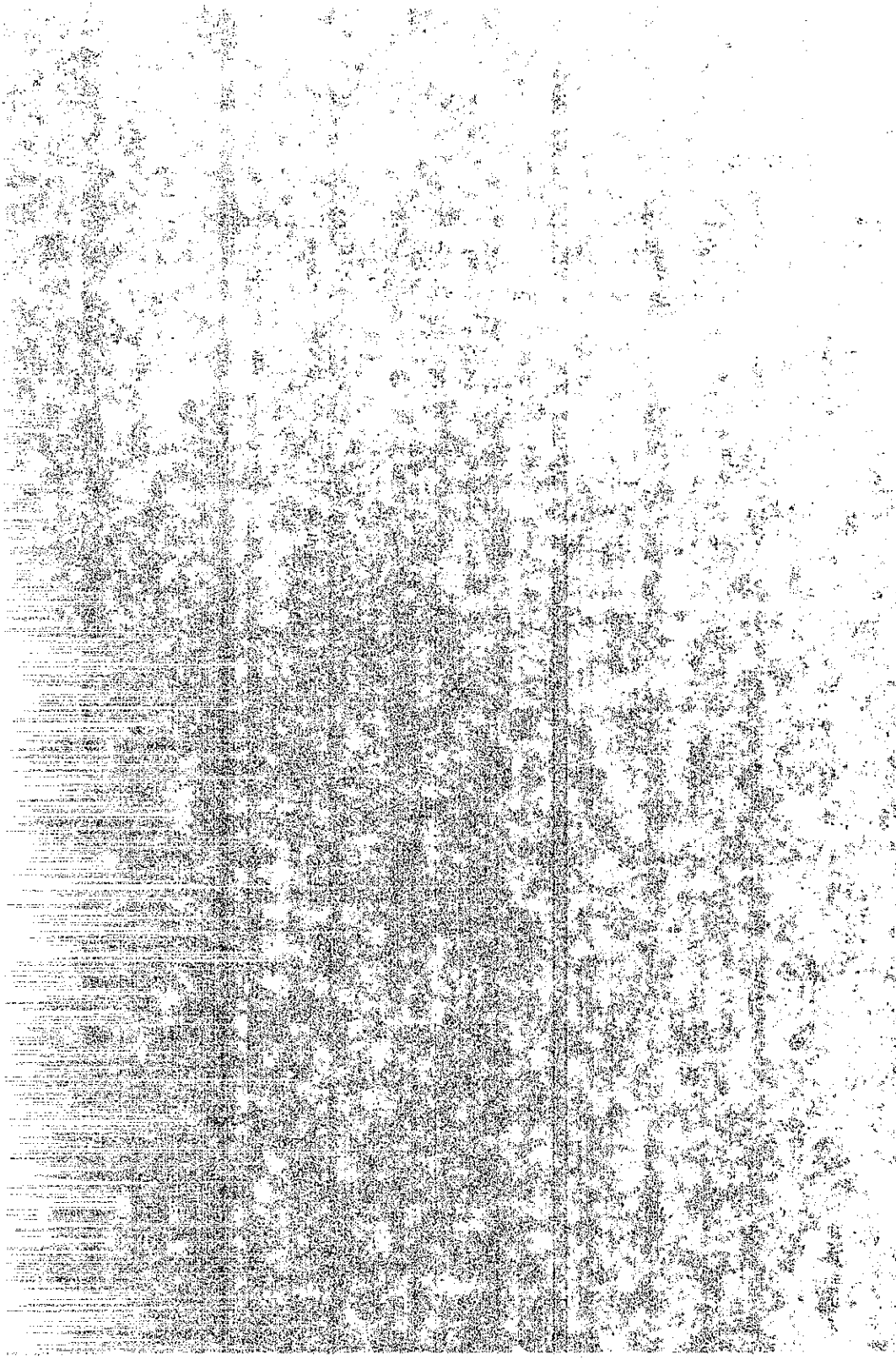
ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the District 07 construction personnel and especially to Arthur Van Rhyn who was Resident Engineer on the project. Their observations and comments contributed greatly to our research.

This work is being done in cooperation with the U. S. Department of Transportation, Federal Highway Administration (Federal Program No. HPR-1(2), F-8-7).

The contents of this report reflect the views of the authors who are responsible for the facts and data presented herein. The contents do not necessarily reflect the official views or policies of the State of California or the Federal Highway Administration.

This report does not constitute a standard specification or regulation.



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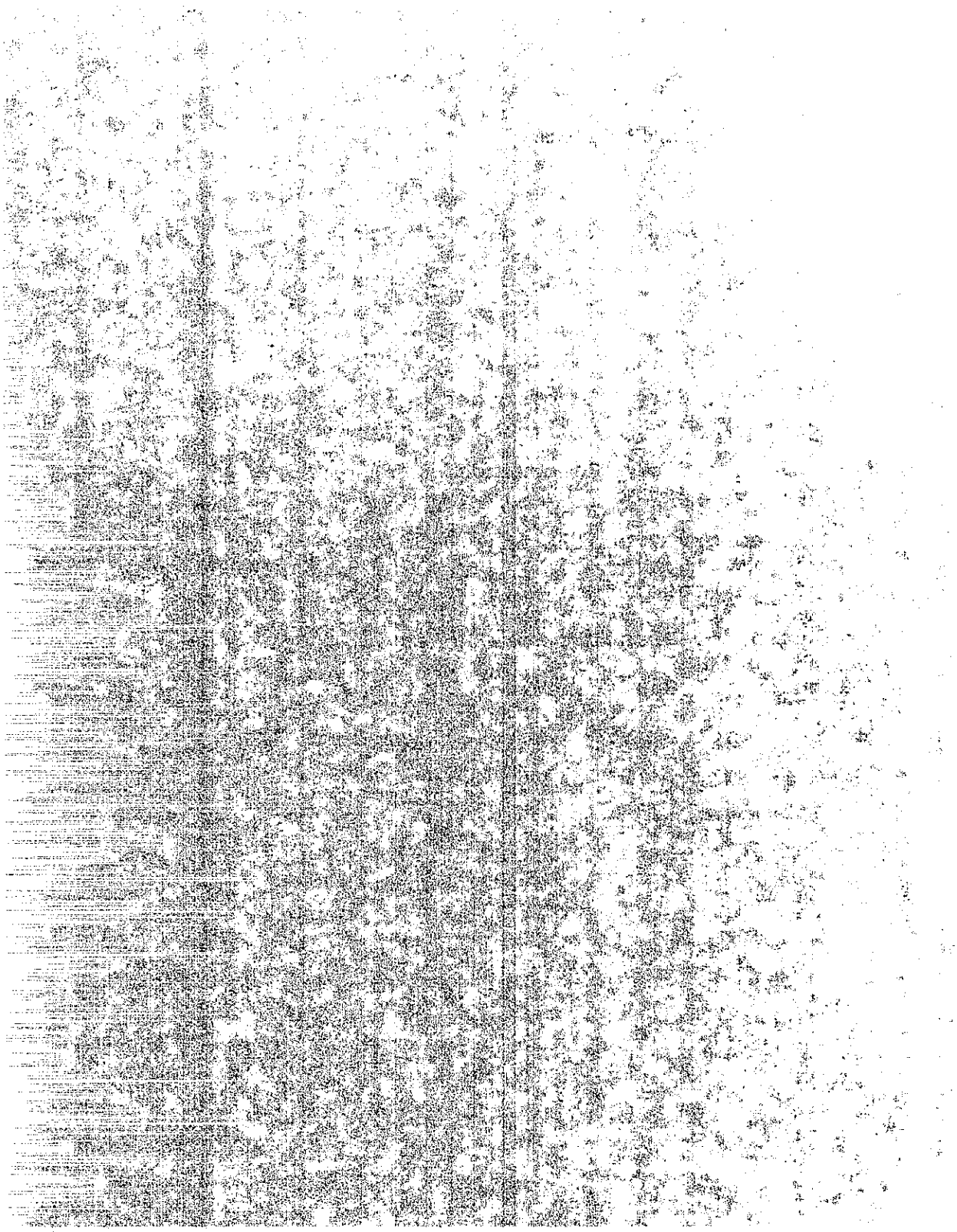


INTRODUCTION

Presplitting consists of developing a fracture surface along the plane of the desired slope by detonating light explosive charges in predrilled holes along the plane prior to production blasting. Proper application of this technique results in a smooth relatively undisturbed cut face.

The use of presplitting has been discussed in two previous Materials and Research reports titled "Presplitting" November 1970, and March 1972, by Travis Smith, et al. The first report describes presplitting in metamorphic rocks on Road 02-Sis-5, near Yreka. The second discusses presplitting in granitic rocks on Road 06-Ker-178.

In these reports the authors concluded that presplitting can: (1) produce steeper, smoother slopes which require less scaling, (2) produce slopes which are more stable than similar slopes constructed using normal blasting procedures, and (3) reduce excavation quantities.

The firsthand experience and analysis of data from the above projects resulted in presplitting specifications which are currently included in the Standard Special Provisions of the California Division of Highways.

This report, the third of a series, summarizes the Division's experience in presplitting sedimentary rock. The work was performed in two cuts on Road 07-Ven-33-PM 15.5-15.9. The location of the project is shown on Figure 1. Figure 2 shows the location of the presplit cuts within the project. This project was undertaken to repair storm damage caused during the heavy rains of early 1969. The Materials and Research Department was requested to recommend a stable slope design. As a result of the investigation, presplitting was recommended for the cut in the vicinity of Sta. 20+. Later it was also decided to presplit a second cut in the vicinity of Sta. 27+ to reduce right of way and earthwork quantities. The statistics for these two cuts are included in Table 1.

The material encountered in these cuts was moderately weathered sandstone with interbeds of weathered shale. Both rock types were jointed. Numerous faults and fault zones also caused discontinuities in the formations. The cut for which this Department recommended presplitting was about 90% massive sandstone with the shale interbeds near vertical in dip (see Plate 1). The second cut was about 75% sandstone which occurred in beds separated by shale interbeds (see Plate 2). The degree of weathering of the rock types and the geologic structure of the second cut suggested problems in the development of a satisfactory presplit face.

Construction of the two cut slopes was accomplished by starting at the top of the hill and shaving off a relatively thin layer of material. This construction sequence imposed limits on the number, size and method of operation of the equipment feasible for the job. As a result, the contractor was required to work, with what was for him a new and untested technique, under extremely difficult conditions.

Because of the massive character of the sandstone in the first cut, it is probable that some blasting would have been required for excavation. However, on the second cut the jointing, the bedded character and the dipping geologic structure suggested the possibility of excavation without blasting, if normal earthwork equipment and techniques could have been used.

The Contractor on the project began construction of the cut slopes using inadequate drilling equipment and unsatisfactory production blasting procedures. This situation, coupled with the lack of necessary experimentation to develop a satisfactory presplitting method for the conditions encountered, resulted in failure to obtain a smooth stable cut face (see Plate 3).

Near the completion of the contract, the Contractor, at the insistence of the Resident Engineer, obtained more satisfactory drilling equipment and experimented with hole spacing and charge size. The results of this experimentation can be seen in Plate 4. The principal differences in the contractors original and final operations appear to be the use of a larger more powerful drill which gave better hole spacing and alignment and a reduction in the size of the production charges. The change in results is readily apparent.

CONCLUSIONS AND RECOMMENDATIONS

Presplitting on this project was unsuccessful except for the lower portion of the cut in the vicinity of Sta. 20±. The reasons for the lack of success were rock of questionable quality, lack of experience of the contractor, inadequate equipment, and failure to perform the experimentation necessary to learn how to achieve acceptable results. The latter three probably could have been eliminated by strict adherence to the specifications throughout the project.

The anticipated savings in the right of way and excavation costs were never realized. The additional costs of redesign and relocation of the road, and maintenance costs associated with rockfall from the steep and unstable slope have made presplitting an expensive procedure on this project.

It should be noted that the original plan did not include presplitting at the second cut location (Sta. 27±) where the problems were most severe and the correction and maintenance costs are greatest. This suggests the danger of extrapolating a cut slope design recommendation to another area without a thorough geologic investigation.

It is worth noting that with adequate experimentation and proper equipment, satisfactory results were obtained in the cut at Sta. 20±.

To prevent a recurrence of the problems encountered on this project, it is recommended that presplitting not be used in borderline rock unless the necessary experimentation has been successfully completed. The experimentation provision is included in the specifications and should be rigidly enforced.

Also, no recommendation for presplitting should be extrapolated without a detailed field review by an engineering geologist familiar with the presplitting technique.

Presplitting should be considered for all cuts in which the material will require blasting for excavation. In spite of the problems on this project, the technique was made to work and past experience indicates that definite benefits can be derived from presplitting.

IMPLEMENTATION

The knowledge and experience gained by this Department on this project is being used as a basis for recommending presplitting on other projects.

The Department has conducted meetings to inform Headquarters and District personnel of the current state of knowledge concerning presplitting. Additional meetings of this type are planned.

The specifications used on this project are included in Appendix A. As a result of experience gained on this and other ongoing projects some changes in the specifications have been recommended for inclusion in the Standard Special Provisions. These recommended specifications are included in Appendix B.

METHOD

In presplitting, the following six interrelated factors require consideration:

1. Boring diameter
2. Boring spacing
3. Boring length and alignments
4. Type of explosive
5. Quantity of explosive
6. Pattern of placement of explosives

On this project as on previous projects, no attempt was made to completely define the relationship between these factors. Unlike previous projects, however, the specification requiring experimentation to develop a relationship that would produce an acceptable presplit slope was not strictly enforced until most of the excavation had been completed. Consequently, most of the presplit slope area produced on this project is unsatisfactory. The major deficiencies in the method used appear to be too large a quantity of explosives, resulting in overblasting, and poor presplit boring alignment and spacing.

Boring Diameter - All presplitting holes on this project were 2-1/2 inches in diameter. This size is compatible with the readily available explosives and drilling equipment.

Boring Spacing - Spacings of 3 and 4 feet were used on this project with the 4-foot spacing yielding the better slope. The apparent reason that the 4-foot spacing was superior was the overall reduction of explosive energy.

Boring Length and Alignment - Boring lengths varied from 12 to 25 feet with 20-foot lifts being preferred and used most commonly. This preference is based on less spalling from drilling offsets and fewer offsets. Alignment could not be properly evaluated because of the apparent overshooting which destroyed most of the hole traces.

Type of Explosive - The contractor on this project elected to use Hercosplit, a continuous column type explosive. This is a 65% dynamite manufactured by the Hercules Powder Co. in 7/8" x 24" cartridges. These cartridges are assembled in the field to form the continuous column. Also used was Gelamite, a 50% dynamite manufactured by Hercules.

Quantity and Placement of Explosives - On this project the contractor used a solid column presplitting explosive, equivalent to 1/4 pound of explosives per foot of boring. A bottom charge of three 2" x 8" sticks of Gelamite was used to insure fracture at the bottom of the lift.

CONSTRUCTION PROBLEMS

Testing - Testing is imperative to determine the correct explosive quantity and spacing, as well as bore hole spacing. The lack of such testing and resultant poor quality slopes on this project are vivid illustrations of this.

Scaling - According to the Resident Engineer and the presplitting inspector, the highly fractured nature of this material and the apparent overblasting on this particular project resulted in no reduction of the amount of scaling required.

Drilling - The jointed and faulted nature of the rock and the contractor's use of drilling equipment not designed for presplit drilling resulted in a serious boring alignment problem. When the proper drilling equipment was obtained it was possible to make borings which met our specifications.

Blasting - The hole traces exposed in Plate 5 exhibit a phenomenon which has been observed in nearly all presplit borings on which the continuous column explosives have been used. It is believed the crack in the back of the hole and extending into the hill represents a significant disturbance of the material in the cut face. This crack is apparently caused by an excess of explosive energy for the quality of material to be presplit.

One other problem that occurred on this project was overbreak from the production blasting (see Plate 6). A basic objective of presplitting is to leave the rock in the cut face in an undisturbed state. On this project, the contractor used an irregular and close hole spacing for his production blasting believing that this was necessary for project conditions. In addition, these holes were loaded with heavy charges. The effect of this blasting method can be seen in Plate 3. The material in the cut face is severely disturbed and unstable.

Failures - Due to the previously mentioned construction shortcomings, this area has experienced a high degree of rockfall (Plates 7 and 8), necessitating many debris benches and excessive widening at grade. This high degree of rockfall creates a maintenance problem, represents a hazard to the traveling public, and makes this an undesirable cut. The overall stability of the slope has so far proved adequate.

SPECIFICATIONS

The specifications used on this project have since been modified because of experience gained on previous projects. The experience gained in sedimentary rocks substantiates those changes and emphasizes the importance of preconstruction knowledge of presplitting principles, methods and specifications. See the Appendicies for specifications.

ECONOMICS

Presplitting - The cost of presplitting includes expenditures for drilling, loading and shooting the presplit borings as well as increased engineering costs attributable to additional inspection. The bids for presplitting on this project ranged from $.70 to $1.00 per lineal foot of presplit boring. Souza Bros. of Yuba City was the successful bidder. The actual cost was estimated by the contractor's superintendent to be $1.30. This figure is consistent with costs on previous projects. A total of $8,449 was paid to the contractor for presplitting.

Engineering costs were not kept separately for presplitting, and thus are unavailable.

Earthwork Quantities - The bids for earthwork ranged from $1.70 to $3.08 per cubic yard with this contractor bidding $1.70 per cubic yard. A total of 192,046 cubic yards of material were excavated at a total cost of $326,479. If presplitting had not been used the design slope would have been 3/4:1 at Station 20+ and 1:1 at Station 27+. Even with poor presplitting these slopes were both constructed at 3/4:1. The non-presplit slope angles would have resulted in the development of 32,461 cubic yards of excavation more than that resulting from presplitting. The reduction in earthwork resulted in savings of $55,184. Although figures are not available, it is estimated that these savings were lost in the cost of relocating the highway. The slopes were so unsafe that the roadway was realigned to reduce the hazard to the motorists (see Plates 7 and 8).

Right-of-Way - The steeper than normally constructed cut slopes resulted in reduced right-of-way requirements. The dollar value of this benefit is not known, although a reduction of the impact of highway construction on property holders and on local tax revenue did result.

Excavation Bids - Although difficult, an attempt was made to determine if more favorable bids were obtained because of the presplitting. No benefit could be detected on this project. However, on other contracts, the earthwork bids appear to be lower because of the reduction of scaling costs and the elimination of local blasting to develop the planned slope.

Safety - No safety benefit was obtained on this project. The poorly constructed and unstable upper portion of the cut at Sta. 20+ and the entire unstable slope at Sta. 27+ were so unsafe that the road was moved out away from the slope to reduce the hazard to motorists.

Maintenance - Because of the rockfall hazard a fence was erected adjacent to the road. Plate 7 shows the rocks that have fallen into the fenced area. Plate 8 shows the damage to the fence and shoulder caused by one of the larger rocks. The extra width appears to be adequate for rockfall catchment as only a few rocks have been reported on the roadway.

Aesthetics - Although difficult to evaluate on an economic basis, aesthetics does deserve mention. A normally constructed cut slope in rock is rough and irregular, while a presplit slope has a clean smooth appearance. On this project the two cut slopes exhibit both types of appearance. The presplit hole traces, which normally are visible and obvious, are seen only locally on this project. One important feature is that the steep slopes possible with presplitting result in a smaller overall scar in the area.

Figure .1

LOCATION MAP

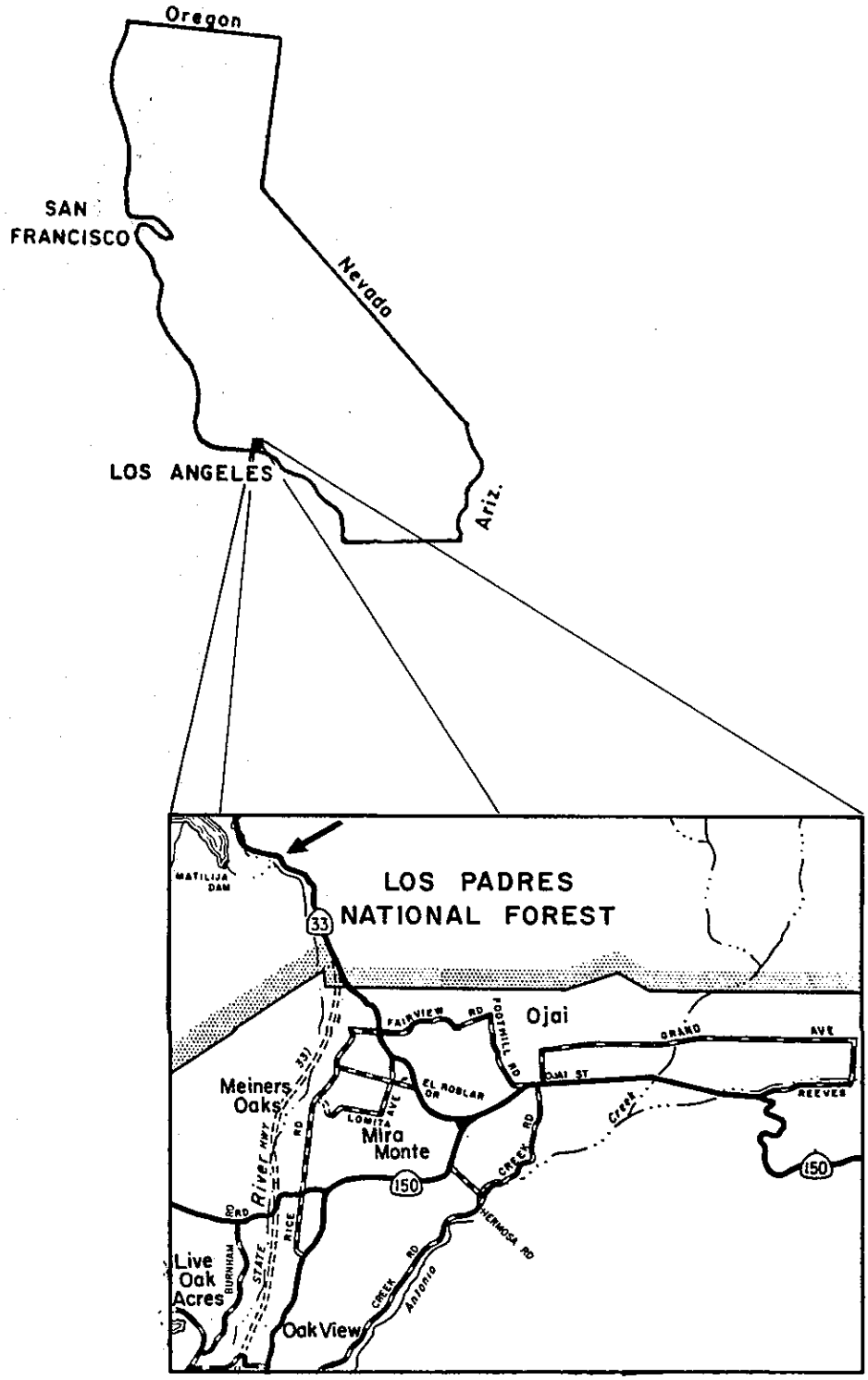


Figure 2

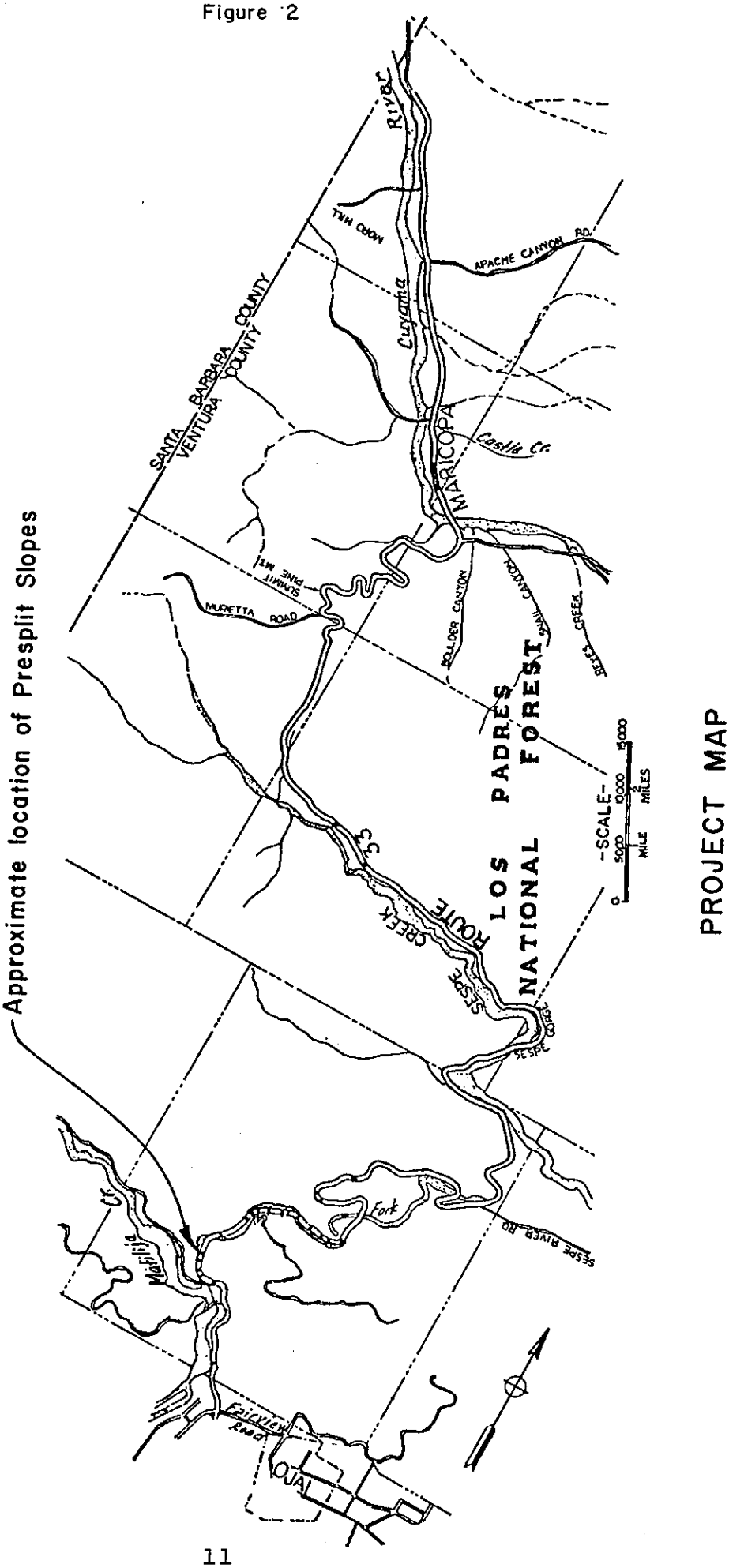


TABLE 1

Cut Slope Statistics

Station	Length	Maximum Height	Designed Cut Slope	Constructed Cut Slope	Excavation Quantity
18+50 to 22+00	350'	147'	1/2:1	Effective 3/4:1 slope; drilled at 1/8:1 with offsets for 20' lifts and benches	
			30' wide benches at 40' vertical intervals	Benched as designed	95,938.6
25+00 to 29+50	450'	151'	1/2:1	Effective 3/4:1 Slope; drilled at 1/8:1 with offsets for 20' lifts and benches.	
			30' wide benches at 40' vertical intervals	Benches were so unstable as to require removal and slope dressing resulting in a 3/4:1 slope.	96,107.8

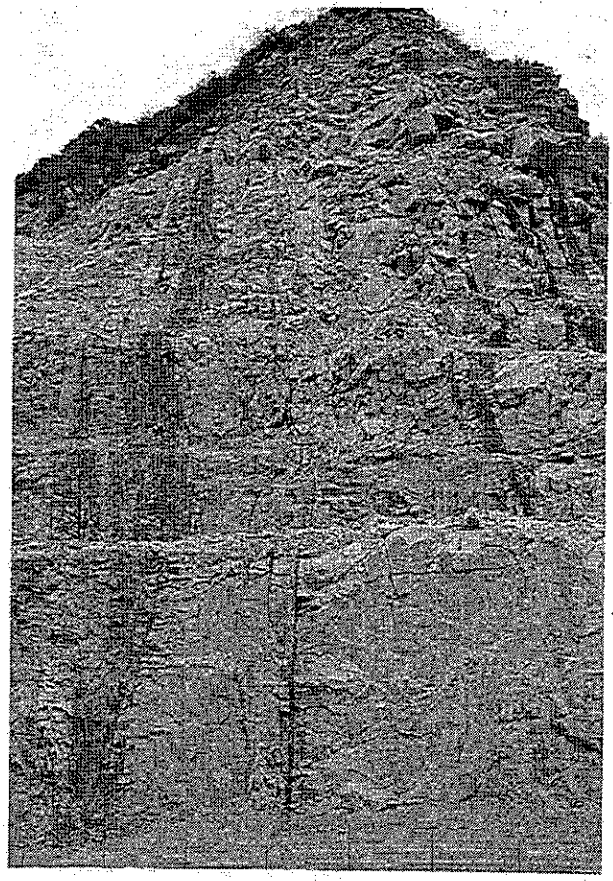


Plate 1 - Sta. 20+

Cut slope appropriate for presplitting

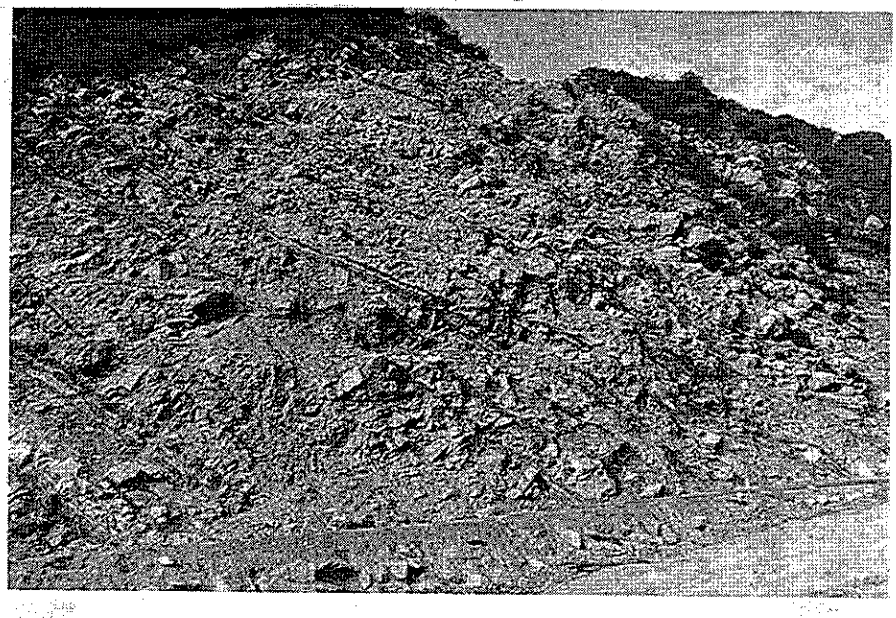


Plate 2 - Sta. 27+

Cut slope marginal for presplitting

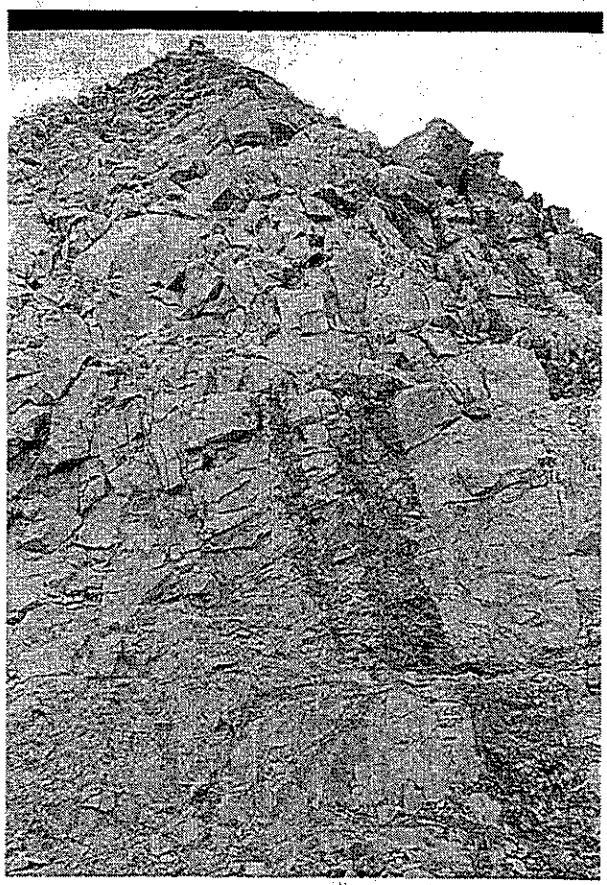


Plate 3- Sta 20+

Unsatisfactory Presplitting

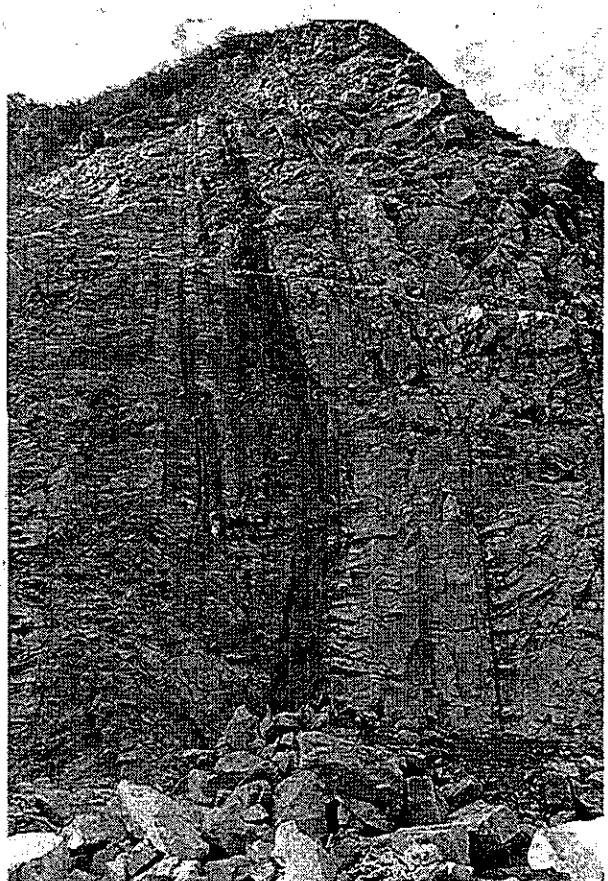


Plate 4 -Sta 20+

Acceptable Presplitting at the Base and Unacceptable at the Top.

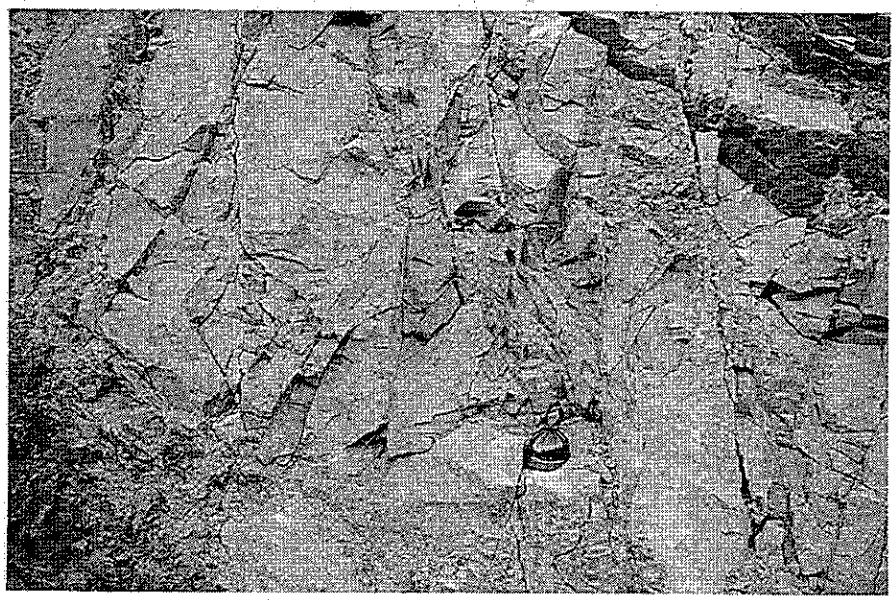


Plate 5

Fracturing of the hole trace due to excessive presplit explosive energy

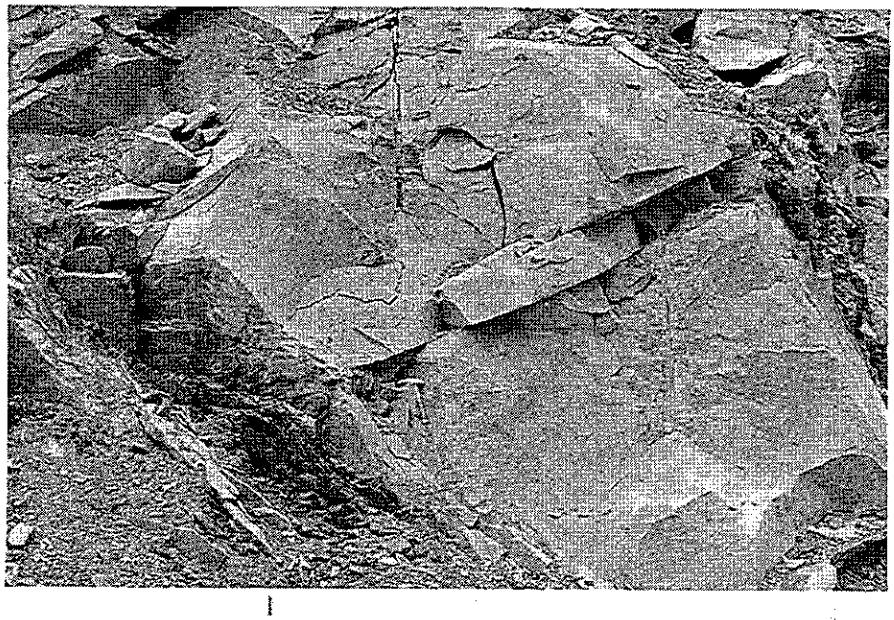


Plate 6

Fracturing of relatively massive sandstone apparently caused during production blasting

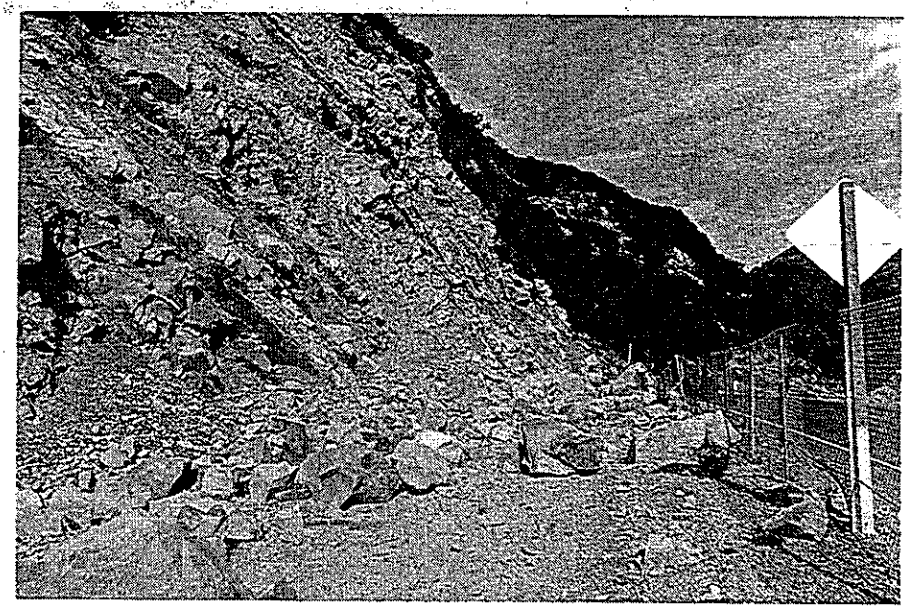


Plate 7 - Rockfall at grade

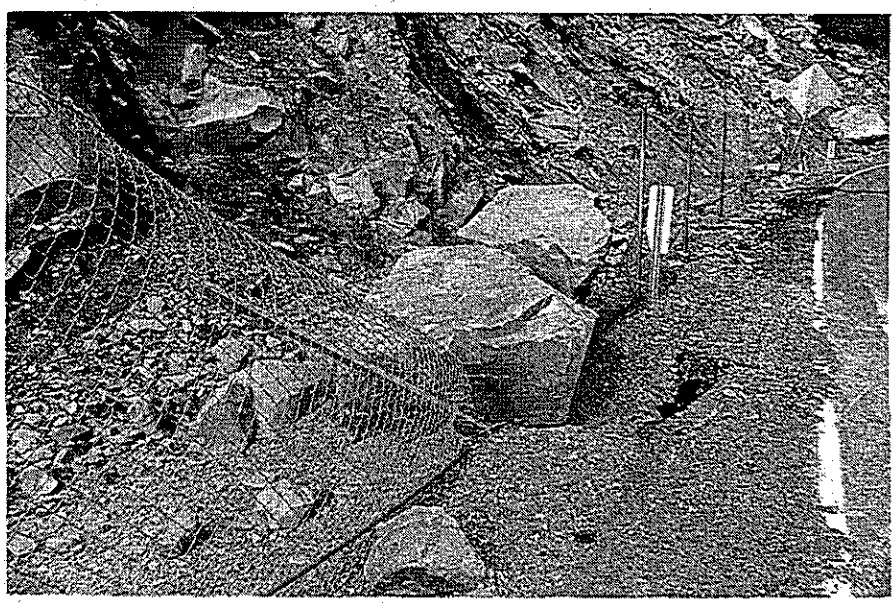


Plate 8 - Size of rocks and illustration of damage potential

APPENDIX A

Project Specifications

11-2.01 PRESPLITTING ROCK CUT SLOPES.-- Presplitting rock cut slopes shall be performed at the locations described herein in accordance with the provisions in Section 19, "Earthwork", of the Standard Specifications and these special provisions.

Presplitting is defined as the establishment of a free surface or shear plane in rock along the specified cut slope by the controlled usage of explosives and blasting accessories in appropriately aligned and spaced drill holes.

The presplitting technique, as covered herein, shall be used for forming rock cut slopes between the following limits:

Station 18+50 to Station 22+00, Lt. of Centerline.

Station 25+00 to Station 29+50, Lt. of Centerline.

The Contractor shall first completely remove all overburden soil along the lines of presplitting to expose the rock surface prior to drilling the presplitting holes.

Slope holes for presplitting shall be drilled along the line of the planned slope within the tolerances herein set forth. The drill holes shall be not less than 2 1/2 inches and not more than 3 inches in diameter. Presplit holes shall be drilled and blasted in lifts not more than 20 feet in height, except that in those areas in which the Contractor has demonstrated that both the alignment and spacing of presplit holes are maintained uniform to provide a cut face on a single uniform plane, the lift thickness may be increased up to a maximum of 30 feet upon written approval of the Engineer.

The Contractor will not be required to use the presplitting technique on slopes 1:1 or flatter.

Drilling and blasting for presplitting shall be kept between 30 and 50 feet in advance of adjacent production blasting operations.

A maximum offset of 24 inches will be permitted for a construction working bench at the bottom of each lift, for use in drilling the next lower presplitting pattern.

The Contractor shall control his drilling operation by the use of proper equipment and technique to insure that no hole shall deviate from a line passing through the hole collar formed by the intersection of the specified slope plane and a vertical plane normal to the specified slope, by an amount greater than 3 percent of the length of the hole being drilled. The Contractor shall

adjust his drilling operations to compensate for drift of previous levels and for the offset at the start of new levels to maintain the specified slope plane, and such adjustments will not be classified as deviation prohibited by this paragraph.

Presplitting drill holes shall be spaced between 1 1/2 feet and 3 feet on centers, as directed by the Engineer.

Auxiliary drill holes along the presplit line, not loaded or stemmed, may be ordered by the Engineer. Except for spacing and payment, auxiliary drill holes shall conform to the provisions for presplit holes.

The Contractor shall presplit and excavate short sections (50 feet to 100 feet in length) to determine optimum spacing and loading of holes at the beginning of each cut and wherever the character of rock changes appreciably.

The Contractor shall place the adjacent line of production holes inside the presplit line (or lines) in such a manner as to minimize damage to the presplit face. The bottom elevation of the production holes shall not be lower than the bottom of the presplit holes.

No portion of production holes shall be drilled within 8 feet of a presplit plane, except as approved by the Engineer.

The Contractor will be required to drill the first line of production holes parallel to the slope line, if necessary to reduce shatter and overbreak of the presplit surface.

Only standard cartridge explosives, prepared and packaged by explosive manufacturing firms, will be permitted for use in presplit holes. These may consist of either fractional portions of standard cartridges affixed to the detonating cord in the field or solid column explosives jointed and affixed to the detonating cord in the field.

The maximum diameter of standard explosives used in presplit holes shall not be greater than 1/2 the diameter of the presplit hole.

If fractional portions of standard explosive cartridges are used, the cartridges shall be firmly affixed to a length of detonating cord equal to the depth of the drill hole, so that the cartridges will not slip down the detonating cord nor cock across the hole and bridge the flow of stemming material. Spacing of cartridges along the detonating cord shall be approximately 12 inches to 18 inches on centers.

If a solid column type explosive is used, the column shall be assembled and affixed to the detonating cord in accordance with the explosive manufacturer's instructions, a copy of which shall be furnished to the Engineer.

A charge of 2 to 3 times the strength of line charges shall be placed in the bottom of the hole. The Contractor will be required to reduce this bottom loading if overbreak occurs.

The top charge of the presplitting hole shall be placed 3 feet from the collar of the drill hole.

Before placing the charge the Contractor shall determine that the hole is free of obstructions for its entire depth. All necessary precautions shall be exercised so that the placing of the charge will not cause caving of material from the walls of the hole.

After a charge is prepared it shall be lowered into the hole and stemmed completely with clean stone chips, all of which pass a 3/8" sieve and at least 90 percent of which are retained on the No. 8 sieve. All presplitting holes shall be completely filled to the collar with stemming material.

All charges in each presplitting pattern shall be detonated simultaneously.

The presplit face shall not deviate more than one foot from the plane passing through adjacent drill holes, except where the character of the rock is such that in the opinion of the Engineer, irregularities are unavoidable. The requirements in Section 19-2.05, "Slopes," of the Standard Specifications shall not apply to cut slopes where presplitting is specified, except that all debris and loose material shall be removed.

As long as equally satisfactory presplit slopes are obtained, the Contractor may either presplit the slope face prior to drilling for production blasting or presplit the slope face and production blast at the same time, provided that the presplitting drill holes are fired with zero delay and the production holes are delayed starting at the row of holes farthest from the slope and progressing in steps to the row of holes nearest the presplit line, which row shall be delayed at least 150 milliseconds.

Whichever method of blasting sequence the Contractor elects to use, the 30 feet minimum advance presplitting provision shall apply.

Any production blasting technique, which results in damage to the presplit surface shall be immediately discontinued.

Presplitting rock cut slopes will be measured by the actual linear feet of holes drilled, loaded, stemmed, and detonated at the locations specified herein.

Those holes that fail to meet the alignment controls specified herein will not be accepted for payment, and holes that are drilled where the finished slope does not meet the slope tolerance specified herein will not be accepted for payment. Only those holes that qualify as to alignment and slope finish and which show undistributed hole trace between the presplitting explosive charges, or if a continuous charge is used show an undisturbed hole trace for approximately 1/2 of the drill length, will be accepted and measured for payment purposes and no compensation will be allowed for unacceptable presplit work.

The contract price paid per linear foot for drilling holes (presplitting) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in drilling, loading, stemming, and detonating, as shown on the plans, as specified in these special provisions and the Standard Specifications, and as directed by the Engineer.

Auxiliary drill holes along the presplit line, ordered by the Engineer, not loaded or stemmed, shall not be considered as presplit holes and shall be paid for as extra work as provided for in Section 4-1.03D of the Standard Specifications.

APPENDIX B

Presplitting Specifications included in the current Standard Special Provisions

Presplitting rock cut slopes shall be performed at the locations described herein in accordance with the excavation provisions in Section 19 "Earthwork" of the Standard Specifications and these special provisions.

Presplitting is defined as the establishment of a free surface or shear plane in rock along the specified cut slope by the controlled usage of explosives and blasting accessories in appropriately aligned and spaced drill holes.

The presplitting technique, as covered herein, shall be used for forming rock cut slopes when designated in the plans.

The Contractor shall first completely remove all overburden soil and weathered rock along the top of the cut for a distance of at least 50 feet prior to drilling the presplitting holes. Particular care and attention shall be directed to the beginning and end of cuts to insure complete removal of all overburden soil and weathered rock and to expose fresh rock to an elevation equal to the bottom of the adjacent lift of presplitting holes being drilled.

Slope holes for presplitting shall be drilled along the line of the planned slope within the tolerances herein set forth. These tolerances also apply to auxiliary holes which are identical to presplitting holes except they are not loaded with explosives. The drill holes shall be not less than 2 1/2 inches and not more than 3 inches in diameter. The Contractor shall control his drilling operations by the use of proper equipment and technique to insure that no hole shall deviate from the plane of the planned slope by more than 12 inches nor shall any holes in the plane of the slope be within one-third of the planned horizontal spacing of any other hole.

The length of presplit holes for any individual lift shall not exceed 30 feet unless the Contractor can demonstrate to the Engineer that he can stay within the above tolerances and produce a uniform slope, then the length of holes may be increased to a maximum of 60 feet upon written approval of the Engineer.

The spacing of presplit holes shall not exceed 36 inches on centers and shall be adjusted to result in a uniform shear face between holes.

The Contractor shall place the adjacent line of production holes inside the presplit lines in such a manner as to avoid damage to the presplit face.

The Contractor may be required to drill the first line of production holes parallel to the slope line at the top of the cut and at each bench level thereafter if necessary to reduce shatter and overbreak of the presplit surface.

Any blasting technique, which results in damage to the presplit surface, shall be immediately discontinued.

No portions of production holes shall be drilled within 8 feet of a presplit plane except as approved by the Engineer. The bottom of the production holes shall not be lower than the bottom of the presplit holes.

A maximum offset of 24 inches will be permitted for a construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern.

The Contractor shall adjust his drilling operations to compensate for drift of previous levels and for the offset at the start of new levels to maintain the specified slope plane.

If at any time the methods of drilling and blasting do not produce the desired results of a uniform slope and shear face without overbreak, all within the tolerances specified, the Contractor shall be required to drill, blast and excavate short sections, up to 100 feet, until a technique is developed that will produce the desired results.

The maximum diameter of explosives used in presplit holes shall not be greater than 1/2 the diameter of the presplit hole.

Only standard cartridge explosives prepared and packaged by explosive manufacturing firms will be permitted for use in presplit holes. These may consist of fractional portions of standard cartridges to be affixed to the detonating cord in the field or solid column explosives joined and affixed to the detonating cord in the field.

If fractional portions of standard explosive cartridges are used, the cartridges shall be firmly affixed to a length of detonating cord equal to the depth of the drill hole so that the cartridges will not slip down the detonating cord nor cock across the hole and bridge the flow of stemming material. Spacing of cartridges shall not exceed 30 inches and shall be adjusted to give the desired results.

If a solid column type of explosive is used, the column shall be assembled and affixed to the detonating cord in accordance with the explosive manufacturer's instructions, a copy of which shall be furnished to the Engineer.

The bottom charge of a presplit hole may be larger than the line charges but shall not be large enough to cause overbreak. The top charge of the presplitting hole shall be placed far enough below the collar to avoid overbreaking the surface.

Before placing the charge the Contractor shall determine that the hole is free of obstructions for its entire depth. All necessary precautions shall be exercised so that the placing of the charge will not cause caving of material from the walls of the hole.

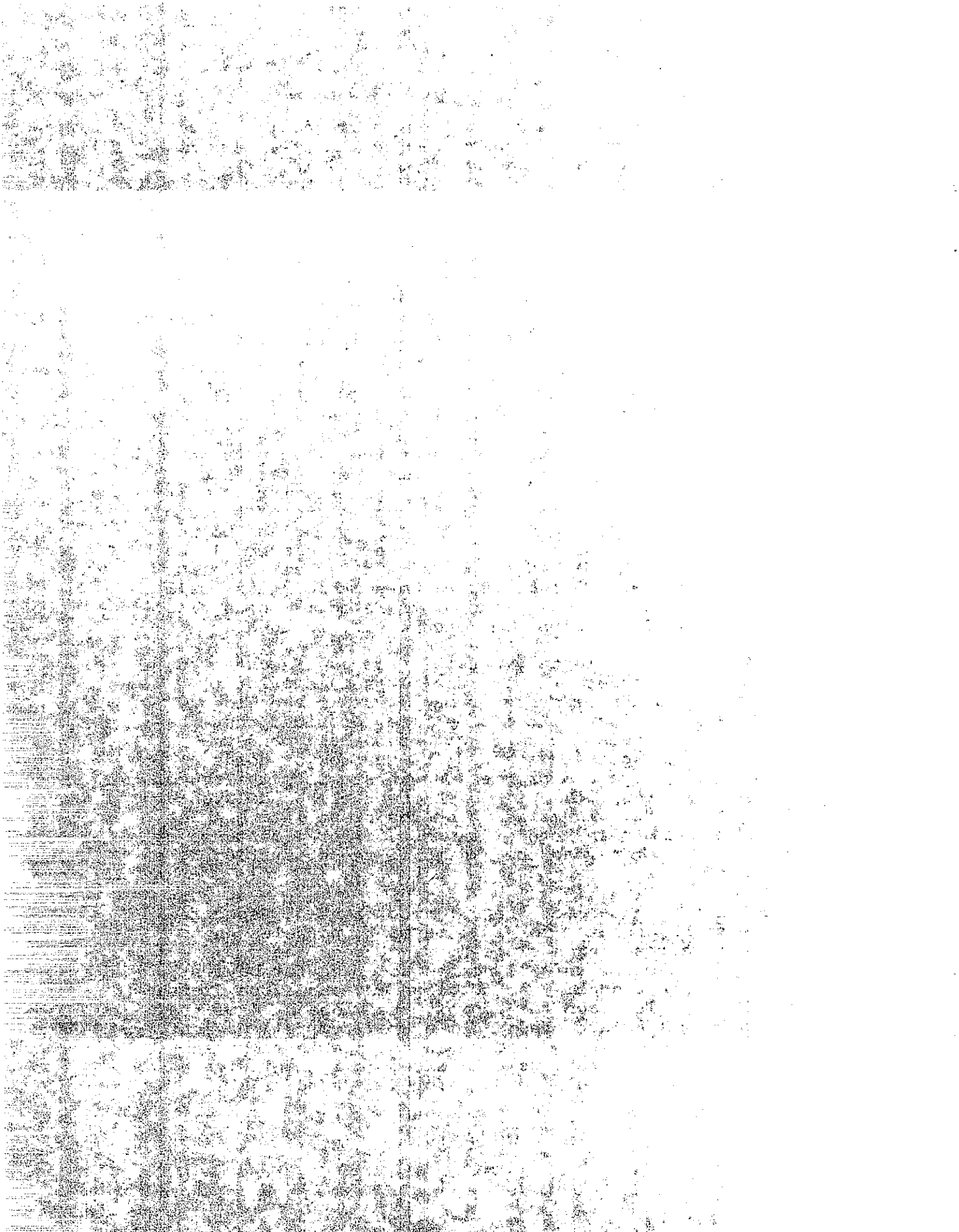
Stemming may be required by the Engineer whenever necessary to achieve a satisfactory presplit face. Stemming materials shall be dry free-running material all of which passes a 3/8 inch sieve and 90 percent of which is retained on a #8 sieve. Stemmed presplit holes shall be completely filled to the collar.

All charges in each presplitting pattern shall be detonated simultaneously.

The tolerance requirements of Section 19-2.05 "Slopes" of the Standard Specifications shall not apply to presplit surfaces of cut slopes where presplitting is specified. The presplit face shall not deviate more than one foot from the plane passing through adjacent drill holes, except where the character of the rock is such that in the opinion of the Engineer, irregularities are unavoidable. When completed the average plane of the slopes shall conform to the slopes indicated on the plans and no point on the completed slopes shall vary from the designated slopes by more than one foot. Completed slopes within 10 feet of grade shall not be more than 0.5 foot full. These tolerances shall be measured perpendicular to the plane of the slope. In no case shall any portion of the slope encroach on the roadbed.

As long as equally satisfactory presplit slopes are obtained, the Contractor may either presplit the slope face prior to drilling for production blasting or may presplit the slope face and production blast at the same time, provided that the presplitting drill holes are fired with zero delay and the production holes are delayed starting at the row of holes farthest from the slope and progressing in steps to the row of holes nearest the presplit line, which row shall be delayed at least 50 milliseconds. In either case the presplitting holes shall extend either to the end of the cut or for a distance of not less than 50 feet beyond the limits of the production holes to be detonated.

Those holes that fail to meet the alignment controls specified herein will not be accepted for full payment and holes that are drilled where the finish slope does not meet the slope tolerances specified herein will not be accepted for payment. Only those holes that qualify as to alignment and slope finish and which show a hole trace for approximately one-half of the drilled length will be accepted and measured for full payment purposes. Those holes which produce an acceptable slope and meet all tolerances and requirements except alignment within the plane of the slope shall be paid for at a rate of 75%



of bid price. Auxiliary holes shall be paid for at a rate of 75% of the bid price. No compensation will be allowed for unacceptable presplit work. Evaluation of presplit holes to determine if they qualify for payment will be made after excavation but before any slope trimming or cleanup work.

Measurement of presplitting hole length for payment of acceptable holes shall be by theoretical slope length as computed from elevations taken before detonating each lift, to be presplit, and a plane 3 feet below finish grade. No payment shall be made for drilling more than 3 feet below finish grade unless directed by the Engineer.

The contract price paid per linear foot for drilling holes (presplitting) shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in drilling, loading, stemming and detonating, as specified in these special provisions and as directed by the Engineer.